VG-1 VAN DEGRAAF GENERATOR KIT

Ramsey Electronics Model No. VG1

It's a rainy boring day, and there is nothing to do but watch sitcoms, YUCK! Do you want to add a little spark to your life? Here's an educational kit designed for the person with an interest in science and high voltage, a neat kit that will produce up to 250,000 volts safely and quickly!

- **Can produce more than 250,000 volts in less than one second; sparks almost one foot long in the right conditions!**
- **Runs quietly from any 12 volt power supply**
- **Motor speed controller available to vary motor speed and terminal current**
- **Created from durable PVC pipe and various other common materials**
- **Everything included that you will need to get the Van deGraaf up and running - and yourself experimenting!**
- **Manual includes many fascinating experiments you can do**
- **Educational, fun to build and safe!**
- **Great value for the classroom and lab - similar units cost hundreds!**
- **Informative manual leads you through step by step to ensure an operating unit when complete**

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- **FM100B Professional Synthesized FM Stereo Transmitter**
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VG1 VAN DEGRAAF GENERATOR KIT INSTRUCTION MANUAL
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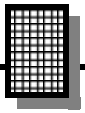

KIT ASSEMBLY
AND INSTRUCTION MANUAL FOR

VG1 VAN DEGRAAF GENERATOR KIT

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RAMSEY ELECTRONICS, INC.
590 Fishers Station Drive
Victor, New York 14564
Phone (585) 924-4560
Fax (585) 924-4555

Introduction to the Van deGraaf Generator

Upon visiting the science museum in Boston, Massachusetts we were inspired by the immensity of the world's largest Van deGraaf Generator. This generator is capable of achieving potentials of a few MILLION volts. It throws quite a hefty spark. It is several feet long and sounds like a large firecracker when discharging. Van deGraaf himself was the one responsible for creating this generator, and it sat behind him in his classroom in Boston, giving the students not only something to remember him by, but an invaluable tool for his study.

You may wonder why in the world anybody would create this crazy thing in the first place. Nuclear experiments require high energies to accelerate particles near the speed of light as well as create X-Rays for the study of the internal structure of atoms and crystals. Dr. Van deGraaf needed something to generate these high potentials, and the technology of the day was not developed enough to begin to think about creating DC voltages in the millions. His solution turned out to be relatively simple, and could achieve these high potentials quickly.

Our version of the Van deGraaf Generator is much smaller than the one we saw in the Museum of Science in Boston, but it can easily achieve some very striking results! While the one in Boston could easily put you to sleep forever without a second chance (evidence is in the 1/4" diameter of the sparks) this version of the Van deGraaf is quite safe. You can impress your friends by allowing the sparks to go directly to your hand, or set up a miniature thunderstorm setup, as well as many other neat tricks!

Let it be known that this unusual hobby of high voltage doesn't seem like much, but it is great fun and soon you will become addicted. You will learn through this interesting kit how high voltage behaves, and safely be able to control it. Soon you will discover that a quarter of a million volts is not enough, and through this kit, you may begin to build your own larger versions capable of much more!

Oh, by the way, just for kicks we left the normally grounded connection on the generator insulated from everything else - making this generator pumpable! This means that you can use a high voltage flyback from a TV and connect it to this ground lead to increase the output voltage of the Van deGraaf, sort of like a series battery connection. This, of course, is recommended only for those with some high voltage background and a willingness to get popped with a nasty jolt when not paying attention!

RAMSEY VG1 VAN DEGRAAF PARTS LIST

ELECTRONIC PARTS

- ❒ 4 1N4002 rectifier diodes
- ❒ 1 1000uF Electrolytic Capacitor
- ❒ 1 1/8 inch power jack
- ❒ 1 PC Board
- ❒ 1 AC-1 600mA wall transformer
- ❒ 1 12VDC hobby motor
- ❒ 1 Power switch
- ❒ 1 4 inch piece of 2 conductor wire (red and black)

PVC PIPE PIECES

- ❒ 1 3 inch to 2 inch adaptor
- ❒ 1 1 foot piece of 2 inch diameter pipe
- ❒ 1 1 3/4 inch piece of 1 1/2 inch diameter pipe
- ❒ 1 4 1/2 inch piece of 1 1/2 inch diameter pipe
- ❒ 1 4 1/2 inch piece of 3 inch diameter pipe
- ❒ 2 endcaps one with one hole, the other with two
- ❒ 1 3” x 3” x 1 1/2” x 1 1/2” Pipe joint (the base)

HARDWARE

- ❒ 6 #4 x 40 1 inch screws
- ❒ 1 #6 x 32 3/8 inch machine screw
- ❒ 1 #6 x 32 3/4 inch screw
- ❒ 2 #6 x 32 locking nuts
- ❒ 1 #6 locking solder lug
- ❒ 1 #8 x 32 1 1/2 inch screw

MISCELLANEOUS

- ❒ 2 8 inch pieces of bus wire (no insulation)
- ❒ 1 4 inch aluminum dowel
- ❒ 1 8 inch piece of aluminum dowel
- ❒ 1 Plastic pulley with 1/4 inch hole
- ❒ 1 Plastic pulley with 5/16 inch hole
- ❒ 2 Large rubber bands
- ❒ 1 1/16 inch thick rubber belt
- ❒ 1 1/32 inch thick rubber belt
- ❒ 1 5 inch piece of grounding braid
- ❒ 1 piece of rubber hose
- ❒ 1 piece of scrap plastic
- ❒ 1 Plastic switch end
- ❒ 2 Stainless Steel Bowls- 3 or 4 quart.

NOTE TO NEWCOMERS: If you are a first time kit builder you may find this manual easier to understand than you may have expected. Each part in the kit is checked off as you go, while a detailed description of each part is given. If you follow each step in the manual in order, and practice good soldering and kit building skills, the kit is next to fail-safe. If a problem does occur, the manual will lead you through step by step in the troubleshooting guide until you find the problem and are able to correct it.

GENERATOR DESCRIPTION

Well now, we see you have some interest in how the Van deGraaf works instead of just slapping it together and guessing at it. We will keep this description as simple as possible, and start off with some simple static generation theories and show how they apply to the generator. We hope you will enjoy this kit as much as we have and learn something in the process.

As you may already know, static electricity can be generated by rubbing two dissimilar materials together, like a wool sweater with your hair, or wool socks on a rug. Actually the rubbing doesn't have as much of an effect on creating the potential voltages observed as the separation of the materials after they have been rubbed together.

When different materials are rubbed together, ions (very small charges such as electrons) are transferred or 'rubbed off' from one material to the other. When the materials are separated, there is a surplus of positive charges on one object and negative charges on the other. The difference in charge between the two objects creates the noticed static electricity. When the potential is high enough, the air which normally prevents the charges from neutralizing each other, breaks down and you see a spark as the charges neutralize each other.

This is the theory on which the Van deGraaf works. If you look at the diagram to the right, you will see a belt running between two pulleys. The friction between the belt and these pulleys is what 'rubs off' electrons from the pulleys onto the inside of the belt. A surplus of electrons produces a negative charge. At the bottom of the generator, a brush is near the point where the belt separates from the pulley. This allows positive ions to be attracted to the negative charge on the backside of the belt to try to neutralize the charge. Since the belt is unconductive, the positive ions can't neutralize the charge, only the attractive field.

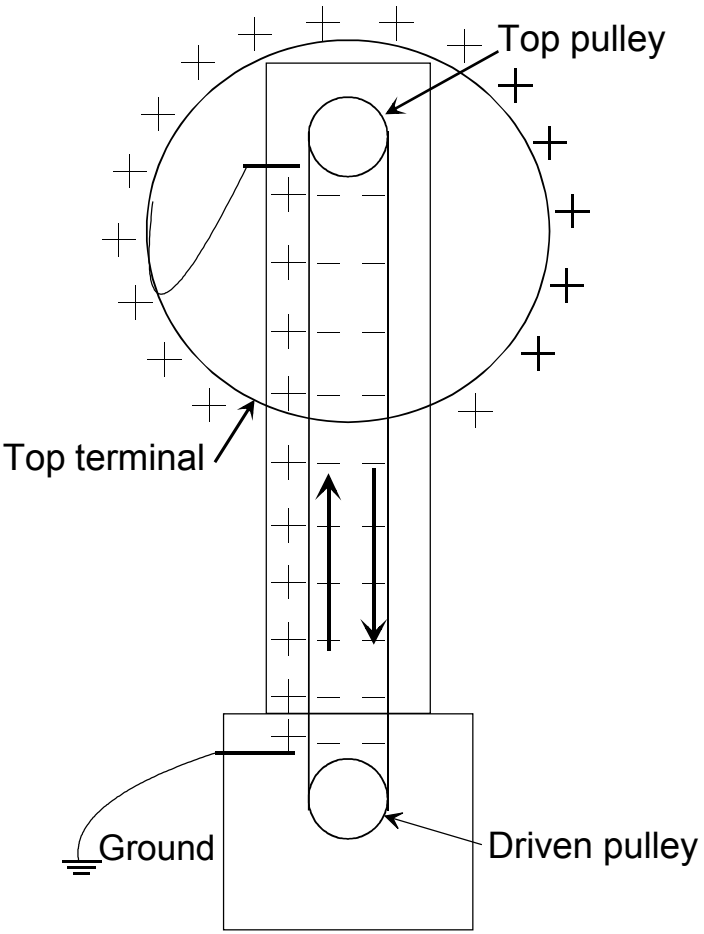
When the belt is rejoined to the top pulley, the negative charge on the inside of the belt is neutralized leaving a surplus of positive charge. This strong positive charge is then picked up at the top brush and transferred to the top terminal where it accumulates over time.

You probably have noticed the metal brushes that help deliver and remove these charges. The reason for using metal brushes is that they have many small sharp edges that deliver charges easily into the air, and they make for a very effective way of delivering charge from the belt.

You may wonder, after looking at the diagram, why the positive charge on the top terminal doesn't prevent the brush from picking up more charge from

the belt since like charges repel? The answer is really neat, because it uses the fact that like charges repel to pick up the charge from the belt. Since the top terminal is round, and all the positive forces are working against each other, the charges are all repelled to the outside of the terminal. To the brush and pulley on the inside, the charge appears to be neutral, so the charge flows from the belt like it would if it were connected to ground!

In theory this top terminal could achieve infinite voltage, but it doesn't due to limiting factors such as leakage currents, air breakdown, and terminal diameter. We will explain some of the limiting factors as we go on with the project, and show you how to reduce them. Now it's time to get on with it!



RAMSEY "LEARN-AS-YOU-BUILD" GENERATOR ASSEMBLY STRATEGY"

The VG1 Van deGraaf Generator kit includes mechanical as well as electrical components. They will be assembled in separate groups to keep things easy to understand. You will be given a description of each component and what function it performs in the project if it performs any at all.

Be sure to read through all of the steps, and check the boxes as you go to be sure you didn't miss any important steps. We know that you're in a hurry to see results but before you switch on the power, check all wiring and capacitors for proper orientation. Also check the board for any possible solder shorts, and/or cold solder joints. All of these mistakes could have detrimental effects on your kit - not to mention your ego!

Kit building tips:

Use a good soldering technique - let your soldering iron tip gently heat the traces to which you are soldering, heating both wires and pads simultaneously. Apply the solder to the iron and the pad when the pad is hot enough to melt the solder. The finished joint should look like a drop of water on paper, somewhat soaked in.

Mount all electrical parts on the top side of the board provided. This is the side that has no traces or pads on it.

Electrical part installation - when parts are installed, the part is placed flat to the board, and the leads are bent on the backside of the board to prevent the part from falling out before soldering. The part is then soldered securely to the board, and the remaining lead length is then clipped off.

Mechanical parts - If you are planning on gluing your PVC pipe parts together, please note the fact that not all joints are glued. Some are left to move for repair or adjustment for smooth operation. When gluing, make sure all pipe has been washed with dish detergent and scrubbed thoroughly, and use ample amounts of PVC glue (supplied at most hardware stores). The more glue on both the pipe and joint the better, but also pay attention to neatness as you'll probably want this kit to look presentable when completed. Make sure that the glue is still wet when you join the pipes together, or you will be touring the hardware store looking for more parts.

CONSTRUCTION OF THE VG1 VAN DEGRAAF GENERATOR

Sort out your parts to begin with, putting the electrical ones aside until later in the completion of your project. The first things we will be working with are the PVC pipes and then we will go from there to more interesting stuff. Make sure and scrub all of the PVC pipe pieces before you continue since they are supplied with anti static coatings to get rid of static charges upon shipping.

For steps 1-4 below, consult Fig. 18.

- ❒ 1. Locate the base of your generator. This is the piece of PVC which has four joints in it, two 1 1/2 inch holes and two 3 inch holes. You will notice that there is a small hole drilled into one side of this piece, and this will be the side that faces you during the duration of the project. The two 1 1/2 inch holes will be angled out and downward.
- ❒ 2. Locate the three inch diameter piece of PVC pipe. This is to be installed on the top portion of the base piece. You may glue these two together if you wish. Read the kit building notes in this manual for some hints on gluing.
- ❒ 3. Locate the smaller (1 3/4") piece of 1 1/2 inch diameter pipe. This pipe goes on the left side of the base piece. This may be glued also. Set this assembly aside for now.
- ❒ 4. Locate the 2 inch diameter piece of PVC pipe and the 3 inch to 2 inch adaptor piece. Glue these two pieces together if you so desire, making sure the slotted end of the 2 inch pipe does NOT go into the adaptor piece. Now that you are done with the glue, put it away so that you are not tempted to use it again, since the rest of the PVC parts need to be able to move.
- ❒ 5. Locate the motor with the two wires attached, the six long screws, and the 1 1/2 inch PVC pipe with the six holes in it.
- ❒ 6. Fire up the soldering iron, and strip back the two wires on the motor 1/4". Pre-tin the ends with some solder before continuing.
- ❒ 7. Verify that the white wire is attached to the motor terminal marked with a positive or red symbol.
- ❒ 8. Verify that the black wire is attached to the motor terminal marked with black or a negative symbol.
- ❒ 9. Screw all six screws into the motor housing PVC pipe about 1/2 an inch. Keep them all screwed in about the same distance, so that when the motor is inserted, the shaft will be parallel with the pipe. (See Fig. 2)

❒ 10. Insert the motor into the pipe, pointing the shaft towards the same end the holes are closest to. The shaft should be visible out the end of the pipe when secure. Keep tightening the screws until the motor is centralized and level within the pipe. Also make sure the screws are not lined up with any holes in the motor's metal casing. (see Fig. 1 and Fig. 2)

❒ 11. Set this part aside since we will be adding the electronics to it later. In the meantime locate the parts needed for the pulley system such as the two motor shafts, bus wire, rubber hose pieces, plastic dowels, and the rubber belt.

❒ 12. Take one of the rubber bands provided and wrap it around the center of the plastic dowel until it is on tightly. The closer this is to the center of the pulley the smoother it will run. (Fig. 4)

❒ 13. We will begin assembly of the lower pulley. Locate the plastic dowel with the smaller diameter hole in it. It will fit quite snugly onto the longer metal shaft. Slide the pulley onto the shaft until it sticks out the other side about 1 3/4 inches. You may need a hammer to gently knock the metal shaft through the dowel. Just don't beat the living @#*&! out of the shaft, since a straight and narrow shaft will result in the best performance. (Fig. 4)

❒ 14. Find the piece of tubing that you will be using for a simple universal joint. (See Fig. 3) This universal joint allows the motor shaft to be at an angle with the pulley's metal shaft. It makes for smoother, more efficient running.

❒ 15. You may now connect the pulley shaft with the motor and set the whole sub-assembly aside for later. (Fig. 7)

❒ 16. Now it's time to assemble the upper pulley assembly. Locate the smaller shaft, the silver colored bus wire, a pencil, the plastic pulley with the larger hole, and the thin rubber belt. First we want to wrap one of the office rubber bands around the plastic pulley tightly, wrapping around the center of the pulley with as few knots as possible.

❒ 17. Find the metal salad bowl with the 2 3/8 inch hole punched into it. This is the bottom half of your generator's terminal. Be careful not to dent or scratch the two pieces of the generator's terminal, as it can decrease performance. Slide the bowl onto the top of the generator base assembly (Fig 18), bottom of bowl (convex side) first. We will get back to the rest of the terminal later.

❒ 18. The next thing we want to do is create dynamic force centering paraphernalia, better known as pulley centering thingumajigs. This is where the pencil comes in handy. Take one of the silver bus wires and wrap it in a tight, neat coil around the pencil. Using wire clippers snip off the parts of the wire you could not fully bend around the pencil. Slide it off the pencil. Voila! a thingumajig! Do the same with the other piece of bus wire. Spring wire is not needed since there will be little if any compression on the pulley parts.

They just keep the pulley centered on the metal shaft. (See Fig. 5)

❒ 19. Take the top pulley (larger hole), the thingumajigs and the thin rubber belt and get ready for some surgeon work. Slide the metal shaft far enough into the hole for the first thingumajig to slide on. Shove the shaft a little further through as you hold the pulley in place so the shaft slides through the pulley. Work the thin rubber belt over the pulley so that it drapes down the pipe. Work the shaft in a little further and squeeze the last thingumajig on the end of the shaft. The shaft should hold snugly in place.

❒ 20. You may as well center the pulley now, stretching and compressing the thingumajigs to get it just right.

❒ 21. At the three inch end of the adaptor, notice that there is a small hole just the right size for a screw. Locate the smallest of the provided screws, the #6 - 32x 3/8 screw. This will be used to set the length of the pipes to adjust tension on the rubber belt. Screw this into the pipe for now, but not all the way through yet. (Fig. 8)

❒ 22. Now it is time to create the brushes for depositing and lifting charges to and from the belt. You will want to locate the grounding braid wire, the small flat piece of scrap plastic, two locking nuts, a #6 - 32x 3/4”screw, and a solder lug provided in the kit. You will also need some solder and your soldering iron again for the following steps.

❒ 23a. Tin each end of the grounding braid to keep the braid from fraying. This takes patience and a hot soldering iron to do the job neatly. Make sure and only solder back 1/4 of an inch from the ends, because you don't want to solder together what we are about to make into a brush. (Fig. 9)

❒ 23b. Cut one piece of grounding braid to about 3 1/4 inches long. The remaining 1 3/4 is the other brush. Frazzle one end of the braid as shown in Fig 9. To make the job of frazzling easier, use a small metal pick or other sharp point to pull the strands straight on one end. Straighten them out about 1/2 an inch back from the end.

❒ 24. When done frazzling the wires, use some snippers or scissors to trim the ends flat across. You will want the brush to cover the entire width of the belt if possible, and if you don't trim it, only the center will be close enough to the belt.

❒ 25. On the shorter piece of braid, about 1/2 an inch away from the soldered end, poke a hole through the center to allow the screw to pass through later.

❒ 26. Install the top brush into the top of the generator base assembly. Notice the slit cut into the side of the pipe where the brush is to go. To get the brush end into the slit, start inserting one corner of the brush and then begin to push the whole brush in through the slit. After you make sure there are

no stray strands sticking out, slide the flat scrap piece of plastic into the slit and under the braid to hold the braid in place. Next take the remaining portion of the braid and fold it up and over the end of the PVC pipe to hold this in place as well. When the top terminal is finally placed, the part that is folded over the top will be our electrical connection from the terminal to the brush. (Fig. 10)

*For best operation of this unit, you don't want the brushes to actually touch the rubber belt, but to be as close as possible to it. The flatter and neater you cut the ends of the brush, the better it will work. The brushes are what pick up the charge from the belt, so this is one of the most critical areas of your kit.

❒ 27. Locate a 6-32 x 3/4 screw, two 6-32 nuts, the solder lug, and the smaller brush. Bend the smaller brush at a 90 degree angle just above the hole in the braid you made in step 25.

❒ 28. Place one locking nut onto the #6 - 32 x 3/4 screw, locking end last, and screw it on all the way to the head of the screw. Now put on the locking solder lug. Yeah, we know you don't really need two locking pieces together, but it was necessary for being able to tighten wires onto the screw at a later time. (Fig. 11)

❒ 29. Slide the screw assembly into the hole on the front of the base assembly, and while holding it in place, slide the smaller brush on the screw on the inside of the pipe. Make sure the frazzled ends are correctly oriented so as not to get in your way during tightening, and make sure they will point toward the belt later.

❒ 30. Screw the remaining lock nut onto the end of the screw and tighten it down to securely hold the brush in place so that it can't spin on its own.

❒ 31. This is where we finally start joining a few things together to find that we are nearing completion of your generator! This happens to be a free checkoff stage for a little break.

❒ 32. Now take the top PVC assembly and join it with the bottom generator base assembly. Loop the thinner rubber belt over the top pulley assembly. Be careful not to pinch the rubber belt in the pipe joints. When doing this, align the top brush so that it is facing you and on the same side as the bottom brush. When done joining, gently screw in the belt tension adjust screw on the adaptor piece to hold the two pieces together. (Fig. 8 and Fig. 18)

❒ 33. Untangle the rubber belt in the pipe and pull it down to dangle in the bottom piece. Get your motor assembly and slide it shaft first into the right hand joint of the base piece. Guide the shaft and the pulley through the loop in the rubber belt and snugly fit the motor assembly into the joint. (Fig. 12)

- ❒ 34. Find the endcap that has only one hole in it and place it on the left hand piece of the 1 1/2 inch PVC. Guide the shaft through the hole and then tighten the pieces together (DO NOT GLUE!). See Fig 12.

- ❒ 35. Try to spin the belt with your fingers; there should be little resistance, but don't expect miracles, we still have a ways to go.

- ❒ 36. If things tend to be a little stiff, check the thingumajigs up top to make sure they are fairly loose, then try spinning the endcap to find where it allows the belt to rotate most smoothly. Finally check to make sure your brushes are barely touching the belt if at all. The closer the better, but the brushes touching the belt cause too much friction for the motor to work against.

- ❒ 37. Well, we are pretty much done with the mechanical assembly stuff. Now it's time to get on with the electrical stuff. We hope your soldering iron is red hot and ready to go!

- ❒ 38. Locate the four diodes, the large electrolytic capacitor, the PC board, two 3 inch pieces of wire, the switch, the power jack, and the remaining end cap.

- ❒ 39. Note the circuit diagram and the PCB layout in figures 19 and 20. Follow these in the next few steps to observe proper part orientation when assembling. If you have any questions as to how to do this, the hints and suggestions part of this manual will give you some tips on how to get started.

- ❒ 40. Install D1, the 1N4002 type rectifier diode. Make sure to correctly orient the banded cathode end. If incorrectly installed, your generator will not work.

- ❒ 41. Install D2, another 1N4002 type diode, observe cathode band.

- ❒ 42. Install D3, a 1N4002 type diode.

- ❒ 43. Install D4, the last 1N4002 type diode. These four diodes form a bridge rectifier which converts the AC from the wall transformer to DC pulses.

- ❒ 44. Install S1, the power switch. Make sure the push button end is headed in the right direction.

- ❒ 45. The last part destined to be added to the PC board is the electrolytic capacitor (marked 1000uF or greater). Definitely make sure this part is oriented correctly as electrolytic capacitors are picky about how they are installed. Generally capacitors have the - lead indicated with a black stripe or - signs, while PC boards indicate the + lead hole. Be sure to observe correct polarity.

- ❒ 46. Ok, now we need to wire up the power jack. Strip back the two ends of

the two conductor wire about 1/4 of an inch. Twist and then tin the ends before soldering to the jack.

❒ 47. Take the two pins on the end of the jack furthest from the plug end and fold them close together. This disables the switch function of the jack. (Fig. 13)

❒ 48. Solder one wire to the two folded together pins, making sure that they are soldered firmly in place. To assist in a good solder joint, try to thread the wire through the holes on the pins.

❒ 49. Solder the other wire to the remaining pin.

❒ 50. Take the endcap with the two holes in it and notice the smaller of the two holes. This is where the power jack will go on the inside of the endcap, but it will be a tight fit. Carefully, so as to not break the jack, use the threads provided on the jack to screw it into the hole. The jack doesn't necessarily have to go all the way in, so once it is tight, stop twisting it to prevent breakage. When done, check it with the jack on the plug in transformer to make sure it plugs in OK.

❒ 51. Put the switch's plastic cap on the end of the switch. Take the end cap and line it up with the PCB switch. Is the jack in the way? If so, gently turn the jack so it is not in the way.

❒ 52. Solder the two loose ends of the wires to the switch's middle two pins on either side. It doesn't matter which wire goes to what side, but if you are undecided, the wire from the folded pins goes to the middle right pin on the switch (look at Fig. 19), and the other wire goes to the middle left pin. Make sure they are soldered firmly in place using the holes in the pins for mechanical support.

❒ 53. Notice the hole on the PCB marked with the + symbol, and the other with the - symbol. The black wire of the motor will be soldered into the - hole and the white one into the + hole. Go ahead and solder these up. (Fig. 14)

❒ 54. Slide the circuit board into the motor housing pipe. It should fit in quite tightly. If not, the remaining #8 x 32 1 1/2" screw is screwed into the unused hole in the motor housing pipe all the way. This is to pin the PC board to the inside of the pipe. When positioning the PC board, slide the endcap on so that the switch can easily be switched when assembled. The screw should meet the bottom of the PC board, and care should be taken to prevent the screw from contacting and shorting two traces at the same time.

❒ 55. Wow look at this! We're almost finished! Check with Fig. 18 to see if your generator is the same so far. If you have messed up, you can fix the problem now.

Firing her up!

- 1. Now is where we separate the electricals from the mechanicals. Make sure everything is attached securely, and get the unit ready to run. Don't bother putting on the top half of the terminal yet as you will likely need to get to the pulley and brush for minor adjustment.

- 2. Using the screw installed in the adaptor piece, extend the pipe for maximum belt tension, and then set the length with the screw.

- 3. Plug in the ol' wall transformer, push in the power switch, and away we go! What no action? This means we either need to reduce the friction in all of the components of the mechanical system, or our electrical system is messed up.

- 4. If the motor doesn't run at all, unplug the wall transformer and then check the construction of the PC board. Make sure all components are soldered well and that you have no solder bridges or cold solder joints. If construction is OK, check part orientation.

- 5. If it still doesn't run, pull the bottom pulley loose from the motor, and fire up the unit again. The motor should be spinning like crazy by itself. If not, you still have an electrical problem. You can use a multi-meter to track it down.

- 6. Once you have solved your electrical troubles, the mechanical ones are a little more finicky. If the pulley is not connected to the motor, reconnect it. Fire it up again to see if it runs.

- 7. If you are running, check the rotation of the belt. It should be going up on the side with the brushes, and going down to the base on the side without. If not you will need to reverse the white and black wires from the motor to reverse the direction of the rotation.

- 8. To get your unit running great, adjust the brushes first for greatest speed by not letting them rub on the belt, then adjust the thingumajigs so their tension is not too great. Then rotate the endcap where the driven metal shaft is visible. When these have been adjusted for maximum performance, try spinning the motor housing to see where it works the best. Ideally, we want the belt to sit evenly on the pulleys and the pulleys to sit evenly on the axles, and the belt not rubbing against the pipe.

- 9. If you have taken only a minute or so to get here, you're either a mechanical wizard, lucky, or not very concerned about getting your unit to run well. Now, adjust the length of the pipes with the set screw so that the belt still runs tight enough to stay on the pulleys, but not loose enough to slip. By now the unit should be running very smoothly.

- 10. Let the unit run for about ten minutes to let the belt work itself in. In the mean time, you can add a drop of household oil to where the shaft comes through the endcap, and to where the top pulley and the metal shaft meet.

- 11. Hold your finger about 1/4 of an inch away from the top brush. You may notice very small sparks tickling your finger or jumping from the brush to your finger. You may need to turn off the lights to see this. Adjust the brushes to increase the rate of spark without causing more friction. This process may involve fraying your brushes some more, or trimming the ends flat across to be able to get more brush closer to the belt. If you see or feel nothing, a neon bulb can be used to check it out. Bringing a lead of the bulb near the belt while holding the other should cause it to glow in a darkened room. To enhance this effect, hold on to the lug on the bottom of the generator while testing for spark.

- 12. If everything is running smoothly, turn off the power to the generator and get the remaining rubber belt and the other half of the upper terminal.

- 13. This part is really tricky, but not too hard once you get the hang of it (especially after the first 10 times). Bring the lower bowl up the pipe so that you can meet the lower and upper bowl together. Use the rubber belt to hold the two bowels together by wrapping the rubber belt around both rims of the globes. If you're like us, the rubber belt will slip off of the back side of the bowl while you slide it over the front. Kind of reminds you of Tupper ware bowls when you want to seal in the stench!

- 14. Once attached, slide the two bowls down the pipe until the top bowl rests on the braid inside. Dust off the bowls with a dry cloth to get off any debris that could be stuck on.

- 15. Fire it up and stand back! You should begin to hear snapping and popping from the top terminal. Turn it off and discharge it with your hand if you are not a chicken, otherwise discharge it by taking a clip lead from a grounded object such as a metal pipe and touch it to the top terminal.

- 16. For final hook up, find a long piece of wire (approx. 10') to use as a grounding wire connection. Solder or screw one end to the solder lug on the generator base, and solder a clip lead to the other. The clip lead will be the connection point where you connect the unit to earth ground such as a water pipe or other similar grounded object. Now if you wish you can make a discharge rod shown later in this manual to help you draw some good sparks.

- 17. With the whole unit together, flip it upside down onto the bowls. Run a bead of silicon sealant around the gap between the pipe and the bowls. Use your finger to make a neat, sealed joint. Let the glue dry for a few hours before flipping it back over.

TROUBLESHOOTING TIPS

PROBLEM: I had a long spark once, but now I can't get a long one anymore.
SOLUTION: The fountain of youth! No, not really, this is caused by a number of different possibilities. The first and most likely is that you have picked up a piece of dust on the terminal, and it has created a leak. Now all you have to do is turn the unit off and dust it. Fire it back up and you should be able to get big sparks again. If not, then you will want to check your mechanical system out for a possible breakdown. Also note that humidity plays a major role with spark length, the higher the humidity, the shorter the spark.

PROBLEM: As charge builds up in the top terminal, the motor slows down.
SOLUTION: There is no solution to this other than buying a tougher motor, but the cause is interesting enough to note here. When the terminal voltage gets high enough, not all the charge is removed from the belt anymore. This results in some left over charge creating attractive forces between the belt going up, and the returning one. This force causes the belt to tighten on the pulleys thereby creating more friction. Neat huh?

PROBLEM: Nothing! Nada! No zip whatsoever, even though the motor is running.
SOLUTION: Check the belt for any foreign substances like water, oil or dirt. If there is a lot of stuff on it, wash it off with dish detergent and water, let dry, and try again later. Otherwise, check belt rotation direction to make sure the belt goes up on the side the brushes are on.

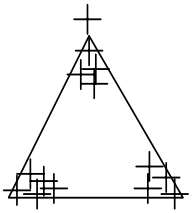
PROBLEM: Wall transformer gets hot, no I mean REALLY hot!
SOLUTION: You haven't adjusted your generator to minimum friction well enough. When there is a lot of friction there is a lot of current draw from the motor. This causes the transformer to get hot as well as the motor. The answer is not a bigger transformer - that will only cause the motor to burn out.

SOME HIGH VOLTAGE INSIGHT :

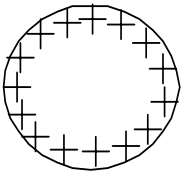
High voltage is a 'somewhat' predictable force of nature. The 'somewhat' is the tricky part to deal with because there is a certain amount of uncertainty involved due to atmospheric conditions all the way from microscopic to macroscopic. That is one of the many reasons why lightning zigzags through the air instead of having a straight path, and it decides to go to a maple tree instead of a taller pine tree. We will describe why some of these variances exist in nature, and how not to get caught by surprise.

With the voltages we will be working with, the attractive and repulsive fields are very strong. As we may already know, like charges repel and dissimilar charges attract. This gives rise to many phenomena involved with the Van deGraaf Generator such as the brushes and the top terminal. You can't help but notice the difference in shape between the brushes and the top terminal. The brushes have many small sharp points, while the top terminal has one smooth surface (disregarding the lips of the bowls).

Sharp objects "leak" charge into the air easily due to the strong repulsive force of like charges. If you look at the diagram to the right you will see that the charges in the triangle are forced to the very ends of the points since all of the charges are repelling each other. At the tips the force is strong enough to repel the charge right into the air. The sharper the point is, the more easily it can be forced off the end.



Large round objects are sort of the reverse of sharp objects. The forces acting on the charges spread the charge evenly over the surface, so the charge in any one place is not much greater than the other. Of course if the charge is high enough on the entire surface, it will leak to the air as well. You will see this on the generator if you let it stand free running.



This is why the lightning rods on barns are so effective. The charge induced on the ground from the cloud above causes the field to be so strong that ions (charged particles) are drawn off of the tips of the lightning rods. Since the charge flows very easily from sharp points, the hope is that the point will discharge the field before the air finally breaks down in the form of lightning. If lightning rods had round terminals like the generator has, they would be ineffective, since they would not deplete the field in the air nearly as well as a sharp point. This is also the reason why lightning would rather strike a maple tree than a pine tree. Pine trees are bristling with sharp points.

The 'somewhat' comes in when you find the pine tree blown into toothpicks! If the field of high voltage increases so quickly that the sharp points can't reduce it, the air will break down anyway. So much for theory!

Many atmospheric factors affect high voltage fields: Amount of leakage, color of spark, air pressure, humidity, and field strength to name just a few. Humidity on the ground plays the most important role when it comes to maximum terminal voltages. The higher the humidity, the more easily charges

can be carried away in the air. For example if you ran the Van deGraaf on a hot, humid summer day, you may draw sparks only 4 or 5 inches long. The same generator on a dry winter day can crank out sparks up to 1 foot in length. What is happening is the humidity on the summer day can remove the charge fast enough that the terminal voltage is kept lower than on the winter day.

Spark color is effected by several different factors, but mainly the air's ability to conduct once it has broken down. The more conductive it is, the whiter and hotter the spark is going to be. This is due to the amount of current available to ionize (break down) the air.

Once ionized, air becomes quite conductive, (several ohms per inch in fact) and releases a purple color due to the nitrogen and oxygen in the air. That's compared to several million ohms per inch before the air breaks down. This "channel" of ionized air is where the current of the spark flows, and heats the air very rapidly. As the air is heated, it expands, creating the tell-tale 'POP' we hear as well as heating the air to incandescence. Incandescence means the same thing as the heating of a light bulb filament. The hotter it is, the closer to white, and then on to blue it is, just like the stars.

Ionized light is like the light coming from neon signs and lasers. For very small, light sparks you may notice the purplish color of ionized nitrogen, or rarely, the reddish color of ionized oxygen. This is due to the fact that the air has not yet reached the point of incandescence and is limited by the low current availability of the spark.

High voltage fields affect the shape and pattern of the spark. Here is where microscopic differences in the atmosphere play a big role. The higher the differences in field strength, the more direct the route of the spark will be. A large area of a spread field will result in spark with very intricate shapes. You can easily observe lightning performing this in a large spread out storm as it traces really weird paths across the sky that go in all sorts of oddball directions. In small, powerful storms you will see fairly straight bolts. The same is true with your Van deGraaf.

Now we will go on to some experiments which will demonstrate some of these factors and more. There are many interesting things to observe with this kit, and you'll never see the same spark twice, unless you photograph it!

Hints and Suggestions:

Making a grounding rod: (Fig. 15)

A grounding rod is a very useful tool to help you discharge objects at a safe distance, as well as prevent charge build up on your own body. Wood is used as a handle to assist in the discharging of your body. Wood is slightly conductive so it can slowly pull the charge away from you while you use the generator.

Use the diagram to get an idea of how to make a simple grounding rod. Just make sure there is a firm solid connection for all of the wires and parts. You will probably want a large round object such as a cabinet knob or large ball bearing with a hole drilled into it. Round cabinet knobs are the easiest since you can find them in any good hardware store, plus they are threaded for mounting onto a screw or threaded rod.

You can make a couple of these with different ending terminals for different types of effects. For example a small knob will result in finer sparks, but a large knob will result in thick sparks. Sharp points can be used to discharge the terminal without a big spark.

Polarity indicating grounding rod: (Fig. 17)

This is more recommended than the first since it will show you many interesting aspects of the creation of high voltage, as well as discharge. Use the same grounding rod created above, but put the circuit shown in Fig 17 in series with the grounding wire. You can twist the leads together and solder them. Then cut the extra lengths off. Be sure to observe the banded cathode ends of the diode. Make sure and mark which bulb is negative and which is positive. You can color the negative bulb with a permanent green marker to indicate negative, and leave the other bulb orange. (All electrical parts available at Radio Shack)

High voltage commandments:

Use only one hand at all times

This is the cardinal rule of working with high voltage. What we do is keep one hand in a pocket, while the other works with the high voltage. This may be difficult to do sometimes, but the trade off is worth it. This prevents your heart from becoming the path of a potentially lethal spark. Though the generator by itself can't harm you, a charged object can. If you get zapped on your hand, the path will be down your side to your feet, and not through the heart!

Rubber soled shoes are useless

We won't let you find out the hard way that the 1/2 an inch of rubber isn't going to keep you from getting shocked. First of all, there is quite a bit of capacitance in your body that can be charged before your body's charge gets high. Once the charge is high, there is no reason why a spark that just jumped

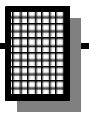
10 inches won't jump around the side of your half inch soles. If you don't like this thought, get a rubber or plastic mat to stand on, or you can use a foot stool. Be careful and use the grounding rod we suggested earlier while your using the generator, otherwise you will get a surprise when you step off the mat because your body will be charged!

If in doubt DISCHARGE IT

Plastic, glass, and other non-conductive objects can act as great capacitors at the kind of voltages we will be working with. Unfortunately you can't see this charge on an object, or even detect it without discharging it. Large plastic and glass objects like a Leyden jar can hold lethal charges easily. Just ask Thomas Jefferson who used the Leyden Jar to kill chickens! Note that these objects can hold charges for weeks or months, so time doesn't play much of a factor in discharging objects for you. For example we charged a 2 foot by 2 foot plastic sheet and even discharged it (not well enough), and moved the sheet three weeks later. Wouldn't you know that the sheet released a nasty spark. If the surprise wasn't enough, the spark almost was! Just be really careful, OK?

Have FUN

The cardinal rule of all kit building. Experiment around and try and discover some really interesting ways of using high voltage. Some people have successfully created anti-gravity demonstrations, mini thunderstorms, and even (not recommended) X-Ray generators. If your appetite for fun isn't quenched with this kit, we have a whole line of all sorts of interesting, fun to build kits at Ramsey. Send to our address or call us for a catalog chock full of goodies!



Experiments

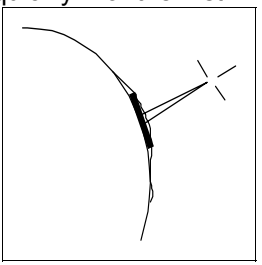
Experiment #1 ***Ion Propulsion***

"For every action there is an equal but opposite reaction." How true Newton's conservation of energy law is. For example if you fire a gun at a target, you will notice the recoil or "kick" of the gun. This "kick" energy is equal in amount but opposite in direction of the bullet and powder gases that were fired out of the muzzle. Of course the more powerful the gun, the more black and blue your arm becomes.

The same is true with charged particles. Though they are much, much smaller than a speeding bullet, they still have a mass and they make up for it in quantity. When ions (charged particles) are ejected off of a surface such as a sharp point, they accelerate to high speeds due to the high fields acting on the

particle. Since they are being accelerated away from the sharp point due to the field on the point, there is an equal amount of force acting to push the point away from the ions. To get a truly noticeable effect though, we will have to eject many ions at high speed.

This is where the Van deGraaf Generator comes in. The high voltages of the Van deGraaf are enough to accelerate lots of ions quickly! For the first part of the experiment we will just observe some interesting features of sharp point propulsion.



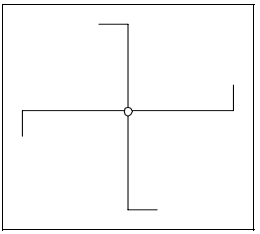
For the experiment you will need a sharp, all metal thumbtack or pin, and a piece of electrical tape. Don't use scotch tape as it will leave residue on the terminal when removed. Poke the pin through the sticky side of a piece of tape. Tape the pin to the top terminal in a direction you can get at. Turn off the lights and fire up the generator and observe the results.

You should notice a small blue "flame" on the end of the pin with the possibility of a buzzing sound. This "flame" is called St. Elmo's fire, and is commonly observed in nature during storms, the color is from ionized gases due to the quantity of charge being emitted. The buzzing sound is from the ions zipping through the air at high speeds.

Try and draw a spark from the generator. Notice anything strange? You shouldn't be able to get a very long spark from the generator at all. The pin is draining the charge away as fast as it is being picked up from the belt.

Hold the back of your hand near the point of the pin and bring it closer and closer to the point. Feel anything? You should feel a breeze of air due to the ions charging the air and propelling the air along with them. If you face the side with the pin you should be able to feel the breeze on your face. If you are on a plastic mat, put down the grounding rod you are using, and hold your finger away from the metal part to draw a spark. This is due to the fact that the traveling ions are drawn to you because of the lack of charge on your body.

In the next part of this experiment we will create a device that will utilize the opposite force to show this ion propulsion. For this you will need some coat hanger or stiff wire (copper house wire is best), a tack, solder, and a hammer. Of course the thinner and stiffer the wire, the better this will work.



- ❒ Cut two 8 inch pieces of wire.
- ❒ Find the midpoints by balancing the wire and hammer a flat spot in both of them.
- ❒ Bend each end to form the shape at right
- ❒ Solder the two flat spots together in the shape at right
- ❒ With a nail make a dent in the center of the flat spot. Balance is crucial so find the center of balance before doing this.
- ❒ Attach the tack to the top of the generator with some tape, and balance

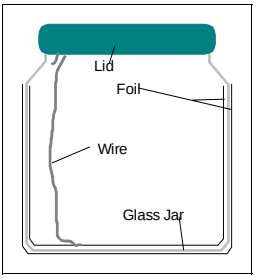
your spinner onto the tack. Try spinning the spinner. It should spin fairly well and stay on the tack.

❒ If it does not, bend and clip wires to get it to balance better.

Now you can fire up the generator and watch what happens. The spinner should go faster and faster. Turn off the lights and you should see a ring of blue where the spinner's sharp points are traveling.

This same propulsion force is used in some satellites to keep them in proper orbits. It is also thought possible to use this force to achieve near light speed travel.

Experiment #2 ***Leyden Jar*** ***(Dangerous! See caution below)***



This simple experiment demonstrates the ability to charge the surface of unconductive materials, in this case a glass jar. Basically we are creating a high voltage capacitor with a voltage rating around 30 KV. You will need a baby food jar with a metal lid, some aluminum foil, and a piece of thin, bare wire (braided preferred).

Tear off two one foot sections of aluminum foil. Wrap one piece carefully around the outside of the jar leaving about 2 inches between the foil and the lid. The smoother it is around the glass the better. You can use rubber cement on the jar to hold the foil in place, or you can tape it tightly around the jar.

The second piece of foil is a little tricky. This one we need to get on the inside of the jar. Rubber cement will help you in this case more than tape. Instead of aluminum foil you can try water with some salt added on the inside, or lots of foil crammed inside the jar. Salt water tends to leak out and make a mess, so it isn't recommended.

Bend the wire over the rim of the jar. Screw the thin wire along with the lid to connect the wire to the lid. The long end of the wire should contact the conductor on the inside of the container but not the outside.

Set the jar on top of the generator and fire it up. Hold your grounding rod terminal to the lid of the jar and wait. You should hear some crackling as the jar is charged. Eventually the potential will become high enough to jump a spark between the foil and the lid. Big enough spark?

CAUTION! CAUTION!

Leyden jar experiments are DANGEROUS! If you don't feel qualified or comfortable with high voltage, don't fool with these experiments. These jars can hold potentially lethal charges so use one hand only at all times to prevent harm. Also don't make yourself a current path by putting your hands across the top of the jar and the sides, otherwise there may be some new interior decorating in the room as you find a strangely human-shaped dent in the wall after your shocking surprise!

After charging the jar again, ground the top terminal of the generator with the grounding rod. **With one hand** pick up the jar by the aluminum foil (don't come close to the lid) and remove it from the generator. Set down the jar and short out the lid and the outside with the grounding rod. If you were to let the jar sit for a few weeks before discharging, it would still have quite a good charge left. This demonstrates how a Leyden jar can store charge.

Experiment #3 ***Transportation of Charges***

This experiment will show how charges are carried by microscopic particles such as dust and airborne water droplets. This will do it on a larger scale with two possible methods, one clean, the other dirty.

The dirty one is the most fun to watch, since it can be done with unsuspecting friends. Just don't perform this experiment in the living room or you will be vacuuming from floor to ceiling!

Collect a bunch of clean, dry sawdust, and put it in a heap on top of the generator. Start up the generator and watch what happens to the sawdust. If you were standing close you have found out that the sawdust is now attracted to any uncharged object in the room, mostly you!

If you bring your hand close to the generator you will be able to see some pieces go zipping back and forth rapidly between the top terminal and your hand. This process is the same as what happens with microscopic particles in the air. For example smoke particles will acquire a charge from an ion air filter, and zip off to the walls. But because of its properties, smoke will stick to the walls, carpet, you and so on. Now ion filters are self contained, so the particles zip off to another grounded filter where they are trapped.

The process of the charged particle going back and forth is an easy one to understand. When the generator is started up, a positive charge is seen on the terminal. This charge then transfers to the pieces of sawdust. Since like charges repel, the force is great enough to cause the sawdust to lift up into the air. When your hand is near, the now charged sawdust is attracted to your uncharged hand. When the sawdust touches your hand, the charge is dissipated. Now the uncharged particle is attracted to the terminal, where it picks up a charge again. This process repeats over and over until the particle gets in a place where the force is not great enough to keep the process going.

The clean method involves using a clear plastic tube fashioned from a report cover, and some treated Styrofoam. If you have some small Styrofoam beads, collect a handful of them and spread them out on a piece of newspaper. Spray them with a light amount of Static Guard which is available in most grocery stores. This causes the outside of the Styrofoam to become partially conductive. This experiment is commonly called "the pith ball experiment". Instead of pith balls, we have Styrofoam ones.

Set up your plastic tube on top of the generator, and pour your foam pieces into it. Place a piece of sheet metal or aluminum foil over the top of your tube. Turn on the Van deGraaf and touch your grounding rod to the top. The balls should start zipping back and forth through the tube like the sawdust does

from your hand to the terminal.

Experiment #4 ***Flying Balloon***

This runs on the same principle as the pith ball experiment, only on a larger scale. This takes some rearranging to perform, but is worth the trouble if you get it going right.

Remove all the furniture but a footstool or desk from the center of a room, and set the Van deGraaf on the desk. Find an aluminum party balloon that is filled with helium to make it float. Let a little helium out at a time and replace it with air. The point is to get it to be the same weight as air so that it doesn't sink or rise up. When you're close to the level point, only let out very small amounts of gas to get it just right.

Once your balloon is hovering, get the generator started. Watch what the balloon does. Even better is to set this up as a game for kids. Get the kids to stay in a certain area near the generator, and let the balloon go. The charged balloon will chase after the uncharged kids, and give them a harmless spark if caught. Kids love this game, though a larger generator would make this more fun. A giant generator makes the game ideal for 'in-law' guests!

Experiment #5 ***Hair Trick***

This is the classic trick that almost everyone is familiar with. Find a plastic foot stool or mat and ask the victim to stand on it. Have the victim place their hands upon the generator and start it up. Soon the victim can feel his/her hair standing up and tingling. If the victim has thin long hair the experiment should work well. When it is a dry day, this experiment will work even better. Grab the person's hand before they get off the stool to give them a surprise.

Experiment #6 ***Anti Gravity??***

Oh come on you say, anti gravity? With this simple device? Yep, there is no question about that. This works on the same principle as the pith ball experiment only this time there is no place for the objects to go once charged. What you need to do to get this experiment going is to make an insulated conductive table and some little space ships out of Styrofoam.

The insulated table is the difficult part and will take some time to put together. This is so because you don't want any voltage leaks on the table, and you don't want to zap yourself when playing. Following is a simple idea which could stand for some improvement later. The diagram describes what you will need to make your table function.

The first step is to cut a 2 foot by 1 1/2 foot piece of stiff sheet metal (aluminum or steel, doesn't matter). Round the corners of the sheet metal to prevent sharp edges. Then take a piece of 6 foot by 1 inch diameter silicon tubing. Run a knife down along the whole tube, slicing it open. Try to cut the slit on the inside of the natural curve of the tubing. Run the tubing along the outside

of your sheet metal; you can use super glue to keep in place, then silicon bathtub sealer to seal the tubing to the sheet metal as well as hold the tubing there. Use some more glue to attach four plastic legs to the table if you want to separate the table from the generator. The longer the plastic legs the better, up to a foot. Otherwise the table sits on top of the generator.

Use Styrofoam and Superglue to make little space ships to put on the anti gravity table. Experiment with different shapes sizes, surface areas, and try Static Guard out for making the ship conductive. The more you create, the better your ships will be. Hint: try a hoverboat shape.

Experiment #7 ***Dead TV***

This demonstrates one way in which a television is damaged when a lightning strike is nearby. This requires the creation of the grounding rod with polarity indicating neon bulbs.

Point the grounding rod away from the generator with one hand. With the other, discharge the top terminal. You should see the lights blink even though no spark was drawn to the grounding rod. This is due to the sudden collapse of a strong electrostatic field when the terminal is discharged.

What has happened is the field from the generator has repelled all the like charges in your body away from the generator. Since the generator has a positive field, the side of your body towards the generator has a negative one, while the side away from the generator has a positive one, which also includes the grounding rod. When the field is discharged, the charges induced in your body and the rod rush to cancel each other. This rush of current causes the lamp to flash, even though there is no complete circuit in the rod.

Now do you wonder why an unplugged TV can still be damaged? Just think of the antennas acting like grounding rods, and the TV acting as you. In many TVs, the tuner transistors can't take more than several volts on them before they are damaged. The blinking of the neon bulbs indicates at least 90 volts!

<u>Photographing sparks and lightning:</u>

If you want to create some very interesting pictures of your sparks to study the fine colors and details that escape the eye during the microseconds that a spark occurs in, then photography is the correct route. One thing is for certain; you will need a camera that you can hold the shutter open on, a good darkened room (like the basement) and some good film, and a little background in photography.

For your sparks from the generator you will probably want fast or hypersensitive film. Film rated at 1000 speed or greater will work great. Set up your camera on a sturdy tripod or shelf and focus in on the area you are planning to work in. If you are not developing the film yourself, you will want to take some normal pictures at the beginning and end of your film roll so the developers don't think that there is nothing on the roll. To do this set your

shutter rate and iris to the proper settings for the film you are using and snap a few.

Turn off the lights and let your eyes adjust. Open the iris of the camera to different settings for each picture you take. Mark down what picture was associated with what settings for future reference. Open the shutter on your camera and let the sparks fly. Make sure and close the shutter before you turn on the lights!

Photographing lightning is just as easy, only you won't need as fast a film as what is required by the generator. Lightning tends to give off much brighter sparks than our generator, and background lighting from street lights would over expose the film quickly. A film speed of 400 or greater will work well.

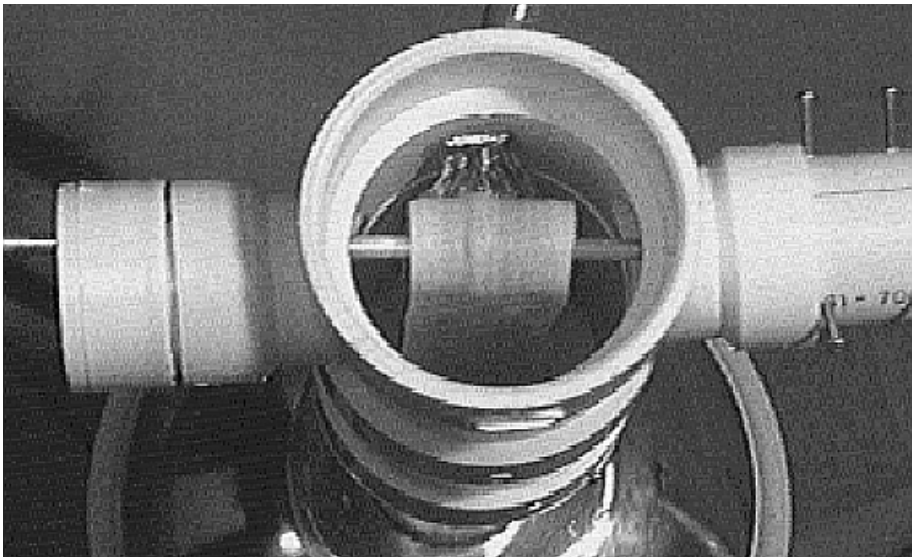
-Mark R. Wyman

Disclaimer:

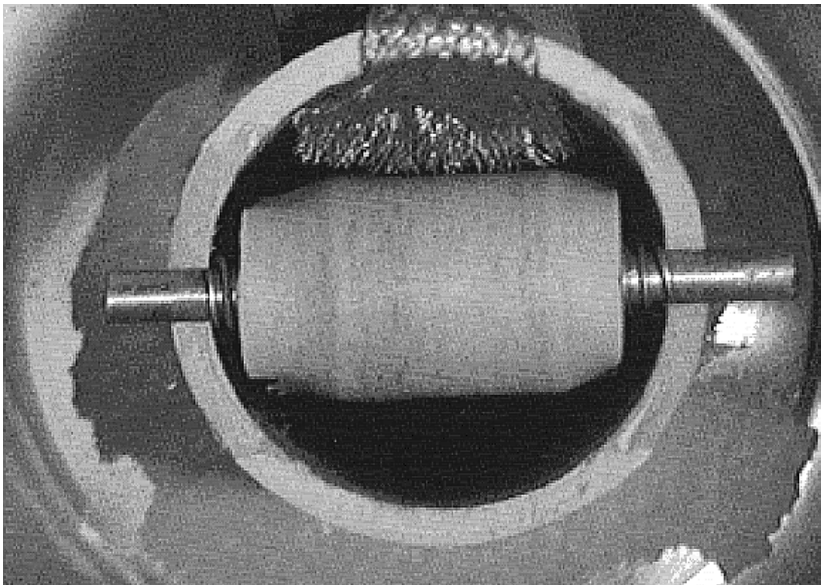
Ramsey Electronics and its employees accept no responsibility when it comes to the use of this kit. We have given you plenty of information on how to safely handle and experiment with this kit. Any charging of large Leyden jars and plastic sheets is considered fooling around with **Extreme Danger**! Don't get one near us, and we don't want to hear about it. Just don't do it. Ben Franklin may have lived through a few zaps, but we can't see everyone being quite as hardy as him, or quite as stupidly daring. We like our kit builders happy, healthy, and alive, so they can order more fun and interesting products from us in the future.

Remember, be careful, be smart, and most of all, if in serious doubt, don't even touch it! Oh... almost forgot. Have FUN!

View of the bottom of the base showing brush belt, and pulley



View of the top of the generator showing brush pulley and hardware



View of completed unit with simulated sparks

Notes and observations:

The Ramsey Kit Warranty

Please read carefully BEFORE calling or writing in about your kit. Most problems can be solved without contacting the factory.

Notice that this is not a "fine print" warranty. We want you to understand your rights and ours too! All Ramsey kits will work if assembled properly. The very fact that your kit includes this new manual is your assurance that a team of knowledgeable people have field-tested several "copies" of this kit straight from the Ramsey Inventory. If you need help, please read through your manual carefully, all information required to properly build and test your kit is contained within the pages!

1. DEFECTIVE PARTS: It's always easy to blame a part for a problem in your kit, Before you conclude that a part may be bad, thoroughly check your work. Today's semiconductors and passive components have reached incredibly high reliability levels, and it's sad to say that our human construction skills have not! But on rare occasions a sour component can slip through. All our kit parts carry the Ramsey Electronics Warranty that they are free from defects for a full ninety (90) days from the date of purchase. Defective parts will be replaced promptly at our expense. If you suspect any part to be defective, please mail it to our factory for testing and replacement. Please send only the defective part (s), not the entire kit. The part(s) MUST be returned to us in suitable condition for testing. Please be aware that testing can usually determine if the part was truly defective or damaged by assembly or usage. Don't be afraid of telling us that you 'blew-it', we're all human and in most cases, replacement parts are very reasonably priced.

2. MISSING PARTS: Before assuming a part value is incorrect, check the parts listing carefully to see if it is a critical value such as a specific coil or IC, or whether a RANGE of values is suitable (such as "100 to 500 uF"). Often times, common sense will solve a mysterious missing part problem. If you're missing five 10K ohm resistors and received five extra 1K resistors, you can pretty much be assured that the '1K ohm' resistors are actually the 'missing' 10 K parts ("Hum-m-m, I guess the 'red' band really does look orange!") Ramsey Electronics project kits are packed with pride in the USA. If you believe we packed an incorrect part or omitted a part clearly indicated in your assembly manual as supplied with the basic kit by Ramsey, please write or call us with information on the part you need and proof of kit purchase

3. FACTORY REPAIR OF ASSEMBLED KITS:
To qualify for Ramsey Electronics factory repair, kits MUST:
1. NOT be assembled with acid core solder or flux.
2. NOT be modified in any manner.
3. BE returned in fully-assembled form, not partially assembled.
4. BE accompanied by the proper repair fee. No repair will be undertaken until we have received the MINIMUM repair fee (1 hour labor) of $50.00, or authorization to charge it to your credit card account.
5. INCLUDE a description of the problem and legible return address. DO NOT send a separate letter; include all correspondence with the unit. Please do not include your own hardware such as non-Ramsey cabinets, knobs, cables, external battery packs and the like. Ramsey Electronics, Inc., reserves the right to refuse repair on ANY item in which we find excessive problems or damage due to construction methods. To assist customers in such situations, Ramsey Electronics, Inc., reserves the right to solve their needs on a case-by-case basis.

The repair is $50.00 per hour, regardless of the cost of the kit. Please understand that our technicians are not volunteers and that set-up, testing, diagnosis, repair and repacking and paperwork can take nearly an hour of paid employee time on even a simple kit. Of course, if we find that a part was defective in manufacture, there will be no charge to repair your kit (But please realize that our technicians know the difference between a defective part and parts burned out or damaged through improper use or assembly).

4. REFUNDS: You are given ten (10) days to examine our products. If you are not satisfied, you may return your unassembled kit with all the parts and instructions and proof of purchase to the factory for a full refund. The return package should be packed securely. Insurance is recommended. Please do not cause needless delays, read all information carefully.

VG1 Van deGraaf Generator
Quick Reference Page Guide

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Photographing 26
Pictures 28

REQUIRED TOOLS

- Soldering Iron Ramsey WLC100
- Thin Rosin Core Solder Ramsey RTS12
- Needle Nose Pliers Ramsey MPP4 or RTS05
- Small Diagonal Cutters Ramsey RTS04

<OR> Technician's Tool Kit TK405

TOTAL SOLDER POINTS
22

ESTIMATED ASSEMBLY TIME

Beginner.....3.5 hrs
Intermediate.....2 hrs
Advanced.....1.5 hrs

ADDITIONAL SUGGESTED ITEMS

- Holder for PC Board/Parts Ramsey HH3
- Desoldering Braid Ramsey RTS08
- Digital Multimeter Ramsey M133

Price: $5.00
Ramsey Publication No. MVG1
Assembly and Instruction manual for:
RAMSEY MODEL NO. VG1 VAN DEGRAAF GENERATOR KIT

RAMSEY ELECTRONICS, INC.
590 Fishers Station Drive
Victor, New York 14564
Phone (585) 924-4560
Fax (585) 924-4555
www.ramseykits.com